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RISK MANAGEMENT AS A BASIS FOR INTEGRATED WATER CYCLE MANAGEMENT IN KAZAKHSTAN

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Abstract
Integrated Water Cycle Management (IWCM) aims to bring together a diversity of social, environmental, technological and economic aspects to implement sustainable water and land management systems. This paper investigates the challenges and opportunities facing Kazakhstan as it its efforts to move towards a more sustainable approach to managing its finite and highly stressed water resources. The use of a strategic-level risk governance framework to support a multi-disciplinary Kazakh-EU consortium in working collaboratively towards enhancing capacity and capability to address identified challenges is described. With a clear focus on addressing capacity building needs, a strong emphasis is placed on developing taught integrated water cycle management programmes through communication, stakeholder engagement and policy development including appropriate tools for managing the water issues including hydraulic models, GIS-based systems and scenario developments. Conclusions on the benefits of implementing an EU-style Water Framework Directive for Central Asia based on a risk management approach in Kazakhstan are formulated.

Keywords: risk management, capacity building, water management, stakeholder engagement

INTRODUCTION

Kazakhstan is facing important challenges in water resource management from a variety of perspectives, including climate change and melting glaciers (Salnikov et al., 2011; Smith et al., 2005; Chen et al., 2013) over usage of river water resources and groundwater systems for irrigation (Dostay, 2012), water pollution by industry and agriculture, and increasing water consumption (Qadier et al., 2009). As a result, ecological crises including the drying out of large terminal lakes such as Aral lake and, more recently, Balkhash Lake are reported (Zavialov, 2005; Turzunov et al., 1997; Dostay, 2009). Figure 1 shows the main Kazakh river catchments, with seven of the eight river catchments identified as being transboundary and thus requiring the establishment of an international water management agreement to peacefully address water distribution conflicts which have been reported (Wegerich, 2008).

Integrated Water Cycle Management (IWCM is a term used in Kazakhstan, which is synonymous with Integrated Water Resource Management) aims to bring together a diversity of social, environmental, technological and economic aspects to implement sustainable water and land management systems (Global Water Partnership, GWP, 2010). It is widely promoted as international best practice with regard to water resources planning to meet the needs of both current and future generations (e.g. Bunting, 2009; EU WFD, 2000; Meyer et al., 2014). The central concept is the development and application of objectives in the form of regional and national catchment-based goals for water management based on each catchment's natural conditions and water usage patterns. It includes the development of knowledge about ground and surface water quality and quantity, evaluation of water resource policy over a long-term perspective, implementation of plans and actions that have been developed collaboratively by all water users to address problems identified, and the on-going monitoring and evaluation of management processes including the development of simulation models and decision support systems as supporting tools for IWCM (Meyer et al., 2014). Any implementation of IWCM also includes the protection of the environment by avoiding overexploitation and/or the deterioration of water resources. It requires the development and modernization of institutional structures, methods, legislation and norms including a range of management skills for building capability, capacity and impact in IWCM and working in partnerships.

The need to strengthen partnerships between business, regulatory and academic sectors at a national and international level was identified by the Kazakh Government, with the areas of environmental protection and water management recognised as priority areas requiring action (Nazarbayev, 2010). It is within this context that the nurturing of a collaborative cross-sector approach to developing capability and capacity of Kazakh graduates in the field of IWCM was the specific challenge targeted by the EU-TEMPUS funded project I-WEB (Integrating Water cycle Management: Capability, Capacity and Impact in Education and Business). In addition to its recognition at a national level, Kazakh members of I-WEB were able to further clarify the scale and impact of the major water resource issues currently impacting Kazakhstan, demonstrating recognition of its importance at a local and sub-regional level. These include increasing levels of water consumption by agriculture, industry (especially the gas and oil industries) and urban areas. For example, whilst modernisation of agriculture is strongly encouraged, it is often linked to increasing water consumption. This is leading to reduction in water levels in both surface and groundwater bodies, the most notable example of which is the Aral Sea (Kostianoy and Kosarev, 2010; Micklin et al., 2014).

Increasing demand for water resources within Kazakhstan is driven by intensifications of agriculture irrigation, industrialisation and urbanisation. Together with the transboundary nature of the majority of its river basins, the need for IWCM plans to balance demands on water resources across economic sectors but also across national boundaries is clear. A further crucial aspect is the need to mitigate the impacts of climate change (current scenarios indicate continuing falling levels of precipitation and glacier run-off with the latter imparticular a key source of drinking water supply within Almaty (the largest city in Kazakhstan). Water pollution is also a major national concern, with water quality in many of its surface and ground waters identified as ‘unsatisfactory’. Discharges of untreated effluents from chemical industries and petroleum processing are identified as principal sources with devastating environmental impacts reported (Lundy, 2014).

A common issue in managing environmental resources at a national or regional level is that it requires inputs from a wide range of stakeholders, each with very different capabilities, agendas, mandates and resources. It also requires an evidence–based assessment of the risks associated with adopting any changes in practice proposed, in association with an assessment of the risks of any ’business as usual’ scenario. The complexity of implementing such legislative requirements within and across national boundaries and sectors requires a strategic level risk management approach that utilises the best scientific and technical evidence to prioritise sustainable decisions but also has the flexibility to respond meaningfully to variations in stakeholder perceptions of what is acceptable or tolerable (Ecologic Institute and SERI, 2010).

As a contribution to addressing this ‘wicked problem’ of water management in a Kazakh context, this paper, maps a strategic risk management approach to developing management capacity. It identifies key methodologies and supporting tools for assisting in the implementation of IWCM and discusses the current status of transboundary basins of Kazakhstan and its neighbours. Finally conclusions on the benefits of implementing a Water Framework Directive for Central Asia based on a risk management approach in Kazakhstan are developed.

Fig. 1 Map of Main River Basins and Rivers in Kazakhstan (Water Resources Committee of the Ministry of Agriculture of the Republic of Kazakhstan, Anonymous, 2004; Map after Duskayev & Minzhanova 2014, changed)

STUDY AREA- CURRENT STATUS OF TRANSBOUNDARY BASINS OF KAZAKHSTAN AND ITS NEIGHBOURS

Water resources are a key for the sustainable economic development of Central Asian states, with Kazakhstan being an exceptionally transboundary- dependent state. Almost all sectors of the economy in these countries are water dependent, requiring huge amounts of water for development. Most of the water resources in the region are transboundary, formed and flowing in from the territory of neighbouring states. Almost 60% of water resources of the country are transboundary and Kazakhstan is downstream almost in all transboundary basins (Table 1). The transboundary water management became a uniquely important aspect of water management in Kazakhstan after the collapse of Soviet Union.

Table 1 Transboundary Basins of Kazakhstan (see also Fig. 1)

Name of the river	Catchment area (km^2)	Riparian states
Irtish	1.643.000	Kazakhstan, Russian Federation, People Republic of China
Tobol	426.000	Kazakhstan, Russian Federation
Ural	237.000	Kazakhstan, Russian Federation
Syr Darya	219.000	Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan
Ishim	177.000	Kazakhstan, Russian Federation
Ili	140.000	Kazakhstan, People Republic of China
Shu	67.500	Kazakhstan, Kyrgyzstan
Talas	52.700	Kazakhstan, Kyrgyzstan

Other smaller transboundary catchments (not shown in Fig. 1) are the Big Uzen (14.300 km²); the Small Uzen (13.200 km²) and the Burla (12.800 km²) of Kazakhstan and Russian Federation; the Aspara catchment (1.210 km²) of Kazakhstan and Kyrgyzstan and the Ugam catchment (870 km²) of Kazakhstan and Uzbekistan. With Russia (Ural River basin and others), Kazakhstan has agreed "least problematic" relations on transboundary river systems, enforcing the Soviet era agreements through water commissions. The abundance of water, resources and a less dry climate made it possible to continue the agreements between Kazakhstan and Russia made within Soviet times (Table 2). However, water quality is a current concern and measures to improve the environmental situation in both in the Urals and Siberia are planned between two countries. Being part of Eurasian Economic Union, the two countries have a strong legislative basis for water cooperation (Abdullaev and Rakhmatullaev, 2013). China, on the other hand, is a major problematic riparian state for Kazakhstan. Although having major economic interests in Kazakhstan, China has made no efforts to improve water cooperation. Despite having Soviet era agreements in force with China, no technical or institutional enforcement mechanisms are in place to monitor their implementation.

Kazakhstan has Transboundary Rivers flowing in from China, Russia, Uzbekistan, Kyrgyzstan and flowing out to the same neighbouring states (Table 1). Two examples from Central Asia show different options of transboundary water cooperation where Kazakhstan is involved. In both cases, Kazakhstan is a downstream country but has applied different approaches in order to receive its water shares from the Transboundary Rivers. Former Soviet Central Asian states have been using water resources of the two largest rivers and many smaller ones since historical times (Abdullaev and Rakhmatullaev, 2013). The Central Asian neighbours of Kazakhstan are linked with Kazakhstan through Syr Darya River, which supplies water Southern part of Kazakhstan. Around 700,000 ha land and around 1 million people depend from the water of Syr Darya River.

Soviet era water agreements and regulations in Central Asia were arranged and monitored by Moscow. The centrally administered and financed water management system has been built to enforce the water agreements among Central Asia states (then Soviet republics). However, frequent water related disputes emerged even in the Soviet period, which was arbitrated by the Central Ministry of Water and Amelioration of the USSR. The Soviet era water agreements were regulated by "normative" documents - decrees of Cabinet of Ministries, assigning water shares to the production system and not to the specific country (state), although national states then translated these allocations into water sharing percentages.

Although, national states (republics) did not openly contest decisions of the centre, in most of the cases arrangements were made in order to sustain own water shares. Therefore, in the mid-1980's the Soviet government felt pressure from the national states and prepared new basin plans for both rivers of the region and launched new institutions - River Basin Organizations (BVO's) for Syr Darya and Amu Darya. These were two serious interventions focused on de-centralizing the transboundary water management in Central Asia. Basin plans clearly predicted development scale and pressure on the river systems of the region and described measures to be implemented in order to balance water situation in the region, including the balancing of the Aral Sea levels. The basin plan included water-sharing percentages among the riparian states. Moreover, the plan proposed measures on improving water efficiency in both basins for the long-term. The plan was a part of the centralized, top-down principles of water (natural) resources management in the Soviet Union. After the collapse of the Soviet Union, newly emerged Central Asian countries agreed to keep this system unchanged and signed an agreement in 1992 (Abdullaev and Rakhmatullaev, 2013).

Since then, countries of the region have made a few attempts to replace the old Soviet water agreement with new one, either for the region as a whole or each for river basin. However, these attempts have not achieved any success. The water allocation in the region is set up through bi-annual meetings of Interstate Coordination

Table 2 Transboundary River agreements of Kazakhstan

Title of the agreement	Place and date of signing the agreement	Agreed bodies and countries	Focus of the agreement
Statement of heads of water economy organizations of Central Asian Republics and Kazakhstan	10-12 October 1991 meeting in Tashkent	State committee on water resources of Kazakhs SSR, Ministry of Water Resources of Kyrgyzstan, Ministry of Water Resources of Tajikistan, Ministry of Water Resources of Uzbekistan, Ministry of Water Resources of Turkmen SSR	Lack of water resources, ecological tension in Aral Sea basin http://icwc-aral.uz/statute2
Statement between Republic of Kazakhstan, Kyrgyz Republic, Republic of Uzbekistan, Republic of Tajikistan and Turkmenistan on cooperation in the fields of joint management, using and protection of water resources of intergovernmental sources	Almaty, 18th of February, 1992	Republic of Kazakhstan, Kyrgyz Republic, Republic of Uzbekistan, Republic of Tajikistan and Turkmenistan	Regulation, protection of water resources, water supply, irrigation Related to all transboundary watersheds and lakes
Agreement between Government of Russian Federation and Government of Republic of Kazakhstan on joint use and protection of transboundary water bodies (and Protocol decision on prolongation of the Agreement)	Orenburg, 27th of August, 1992 (Pavlodar, 26th of June, 1997)	Republic of Kazakhstan, Russian Federation	Protection of water resources, water supply, irrigation, floods, regulation; Related to all surface and ground water resources, including transboundary rivers such as Ishim, Irtish, Ural, Tobol and Volga http://base.spinform.ru/show_doc.fwx?rgn=31129
Statement on joint actions to address the problems of Aral Sea Basin and Aral Sea Region, ecological recovery and providing of socio-economic development of the Aral Sea Region	Kyzyl Orda, 26th of March, 1993	Republic of Kazakhstan, Kyrgyz Republic, Republic of Uzbekistan, Republic of Tajikistan and Turkmenistan	Problems of Aral Sea Basin The Inter-State Council on Aral Sea Basin Problems and its Commission has been established http://online.zakon.kz/Document/?doc_id=1045205
Statement between Republic of Kazakhstan and People's Republic of China on Kazakh-Chinese State Border	Almaty,26th of April, 1994	Republic of Kazakhstan, People's Republic of China	Identification of location of boundary watersheds, middle of boundary rivers or its main streams, belonging of islands on boundary rivers http://online.zakon.kz/Document/?doc_id=1016993
Statement on using of fuel-power and water resources, construction and maintenance of gas pipe line in Central Asian region	Tashkent, 5th of April, 1996	Government of Republic of Kazakhstan, Government of Kyrgyz Republic, Government of Republic of Uzbekistan	Effective using of the hydro resources of Syr Darya river for irrigational purposes. Regulation of working practices of Naryn – Syr Darya cascade of water reservoirs

Water Commission (ICWC), which consists of water ministers of the Central Asian states. Kazakhstan, represented by the deputy Minister of Agriculture in the commission, receives its shares for Syr Darya in the meeting of this body. The decisions are made based on water allocation percentage of the flow and water availability forecasts for the given season (6 month). This agreement retains internationally known historical rights principles. However, currently upstream countries, Kyrgyzstan and Tajikistan, are not happy and are contesting this agreement. The need for energy and abundance of the water resources formed in their territories are arguments used by the two upstream countries to change the pattern of the water use more towards energy generation (Abdullaev and Atabaeva, 2012; Wegerich, 2013).

Kazakhstan has been facing the consequences of the change of water use in the Syr Darya basin, having floods in winter and water shortages in summer due to the energy generation regime in the river. In order to reduce negative impacts of such changes, Kazakhstan has promoted regional energy trade and tried to promote energy exchange with Kyrgyzstan and other riparian states. This was a short-lived strategy and only worked for a short time. Then Kazakhstan took a unilateral approach and built counter-regulations for capturing the water in winter, and strengthened the river bed of the Syr Darya within its territory. In order to enhance its water security in summer Kazakhstan has worked out bi-lateral and mostly informal agreements with Kyrgyzstan and Uzbekistan.

Kazakhstan has also developed a different approach utilising exemplary agreements with Kyrgyzstan on the Chu-Talas basin (Abdullaev and Atabaeva, 2012). In this smaller basin, two sides agreed to work out the agreement on joint management and maintenance of the water infrastructure, which are transboundary. Kazakhstan, being the downstream country, has put funds for rehabilitation and maintenance of water infrastructure located in Kyrgyzstan. The joint basin organization has been set up by two sides in order to institutionalize the water cooperation.

In spite of existing legal and institutional instruments for transboundary cooperation Kazakhstan is facing a serious risk on water security. Moreover, current setting of transboundary system does not respond to environmental and water quality issues, mainly concentrating only quantity aspects. Therefore, inclusion of major stakeholders, namely local – riparian communities into the process of transboundary cooperation will reduce the risk of failure. Application of more integrative and inter-sectoral principles would help to include issues of water quality and environmental maintenance into the transboundary negotiations.

METHODOLOGY

A scoping study and the creation of a project advisory board to facilitate the development of a common understanding of current working practices and emerging challenges was undertaken for clarification of the major risks with regard to water cycle management. Representatives of Kazakh academic, practice, policy and student organisations were interviewed to identify current working practices and emerging challenges. The results of this process are detailed in (NIREAS, 2013) and were used to identify and frame IWCM needs from multiple perspectives.

Building on the initial assessment, the concept of risk governance (IRGC, 2005; Renn, 2008; Renn and Walker, 2008) was identified as a useful framework to link identified strategic and applied components together in a manner that integrated the various functions and showed the relationship between them. Watt (2014a) discusses the origin of such approaches and introduces the first major feature that can be used to begin to understand the relationship between the roles of different actors (stakeholders). This reflects a development that emerged in the USA in the 1980s (NAS, 1983) that: "*Regulatory agencies should take steps to establish and maintain a clear conceptual distinction between assessment of risks and the consideration of risk management alternatives; that is, the scientific findings and policy judgments embodied in risk assessments should be explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies".*

In this context, risk governance can be presented as a conversation between two 'sides' (risk management and risk assessment), which facilitates evaluation of the functions of those responsible for any given task. Policy makers and regulators can be presented as general managers undertaking a risk management function, which may require evidence from scientists and engineers, who are specialists.

RESULTS AND DISCUSSION

The first challenge identified during the interviewing of stakeholders was the need to support stakeholders in developing a strategic vision – a way of looking at the IWCM challenges faced from the top down that would support recognition of how the various components/activities of stakeholders fit together. A further challenge within this was recognition that many individuals come to the practice of IWCM from different disciplines and backgrounds and also may go on to a variety of roles in their professional life. A strategic approach needs to integrate data from specialists, for example engineers and analytical chemists, operating across a range of sectors that can appear remote from each other, and which require very different types of education and training, and yet each has an important role in different parts of IWCM. For example, whilst policy makers may never undertake a technical role, they will be called on to set objectives or develop policy that technical teams will have to implement and which need to be underpinned by high quality science and engineering.

A strategic risk management approach to developing management capacity

A framework for the evaluation of IWCM in Kazakhstan was developed by Watt, 2014b based on the International Risk Governance Council (IRGC) Risk Governance Framework (IRGC, 2005, Renn, 2008, Renn and Walker, 2008; see Fig. 2). The framework separates the process of risk governance into a number of different elements that make the process easier to understand.

The first stage of the IRGC framework, known as 'pre-assessment', highlights the importance of context for anchoring the subsequent risk management to the aims and objectives of the organisation mandated to manage the risk, and discuss ways that the local context can be established with a clear recognition of the benefits of the water being managed. Pre-assessment is undertaken by both managers and technical specialists together, and can framed in many different ways – physical (e.g. hydrology, climate, ecology) and human (e.g. sustainability, economy, use to which resources are devoted). Pre-assessment also evaluates constraints placed on options for risk management by scientific conventions utilised, the law and regulatory arrangements. Within I-WEB, this pre-assessment process involved interviewing a range of stakeholders including policy-makers, practitioners, industry representatives and academics to understand their current working practices, challenges and ambitions (see NIREAS, 2013). This initial needs assessment supported the identification of a broad set of skills required in teaching and practice, encompassing social, environmental, technological and economic aspects of sustainable water-land management. Specific topics identified included water indicators and monitoring (including statistical methods and modelling), geo-information and water treatment technologies and methods to the strengthen cooperative working between diverse actors (e.g. public authorities, universities and research institutes, NGOs, governmental and international organisation), including the relevant laws, finances and management approaches pertaining to surface and ground waters both nationally and internationally (NIREAS, 2013).

Fig. 2 Framework of the functions of the risk governance at strategic level (Adapted from Bunting, 2009)

The second stage, risk appraisal, involved gathering and sharing data from scientific assessments of the water supply and its quality undertaken by several disciplines e.g. hydrologists, climate change scientists, agricultural scientists and economists. Within I-WEB, this stage took the form of a specialist workshop on IWCM methodologies and practices where representatives from a range of Kazakh and EU organisations presented research methodologies, current scenarios and future challenges from a range of organisational perspectives. The outputs of this workshop firmed the basis of the development of the ‘IWCM in Kazakhstan’ handbook (Meyer and Lundy, 2014) which includes concepts of IWCM, methodologies and supporting tools for IWCM, management skills for building capability, capacity and impact, best practice examples for water treatment, basics on the sustainable use of water resources in KZ, a concept of IWCM for KZ and transboundary catchment issues and future integrated management. In the current model, this stage is an extension of the risk assessment referred to by the NAS (1983) in the quotation above to include evaluation of public (or other stakeholder) concerns, which may impact on the way that management options can be evaluated.

The third stage, characterisation and evaluation is the core of the process, best undertaken by all involved, where the evidence from the risk appraisal is evaluated in the light of the organisational values set out in the first stage. This is where a judgement is made on the acceptability of a risk and leads to one of three possible management actions – do nothing, ban some proposed or current activity or manage the risk. Within the I-WEB programme this stage took the form of presenting the results of the pre-assessment process to members of the I-WEB International Activity Board (IAB) for their comment and feedback on data collected and its interpretation. The I-WEB IAB currently consists of over 20 members from a range of academic, policy, and professional/industry backgrounds who voluntarily participate in annual meetings to share knowledge on IWCM challenges within their sectors and comment on I-WEB outputs as they develop to collectively take forward best practice within IWCM in Kazakhstan. This IAB approach is a co-owned mechanism to facilitate the development of closer links between academia and practice for mutual benefit; enhancing the skill sits of graduates and hence graduate employability (through ensuring graduates have the skills employers need) as well as an awareness of the challenges they face.

The fourth stage, risk management, shows how policy or management options can be developed based on the judgement made and implications from the technical evidence. A number of generic approaches were presented taking into account the extent to which stakeholder concerns needed to be incorporated. As an example, if scientific uncertainty was very high, a risk management decision might be required to be made by the government or a regulator to address public concern. In the absence of scientific data this might be made on the basis of a risk philosophy such as the precautionary principle with some form of stakeholder agreement (or societal endorsement) needed on the level of precaution required. Within I-WEB, the management options developed were three-fold involving staff re-training, the development of Bologna-compliant academic programmes and the re-working of programme material to additionally form short continued professional development (CPD) courses. More specifically, using outputs of the stage 1 and stage 2 activities, and following input and refinement of the stage 3 activities, findings derived were used to develop a bespoke intensive re-training programme for 30 Kazakh academics. New knowledge developed was shared both horizontally, through seminars at each participating institution, and vertically through the subsequent development of learning materials for MSc and PhD teaching and research programmes as well as the more vocational CPD courses.

The fifth element of the risk governance framework highlights the importance of communication (both internal and external), by positioning it in the centre of all of the other activities. A number of approaches have been developed depending on the nature of the risk, which is tasked with dealing with it and their relationship to other stakeholders. In I-WEB, communication was both a central challenge (language, cultural and experiential) and a core area of activities, which was addressed through multiple routes with particular focus on developing strong partnership working approaches. The wider context for this is that, together with many other sectors, communication and partnership working is now fundamental to water resource management legislation in many EU and Central Asian countries as its recognised that there are practical limits to the application of a top-down legislative approach as it is often difficult to enforce. It is increasingly appreciated that the existence of legislation alone is not enough to ensure environmental protection, because when water pollution occurs, it is often the result of ignorance and neglect rather than deliberate acts (Chatfield and Lundy, 2016). Over the last twenty years a range of alternative cross-sector partnership approaches have been developed to protect the water environment, involving regulators, industry partners and communities, working together to promote good practice and improved standards. In recognising the success of such, often voluntary, partnership initiatives, legislative frameworks increasingly include a requirement for partnership working as a core element. These include, for example, the EU Water Framework Directive (EU WFD, 2000), the EU Floods Directive (2007), the Integrated Pollution Prevention and Control Directive (EU, 2008) and Strategic Environmental Assessment Directive (SEA, 2001).

Whilst actual data on the benefits of a partnership working approach is hard to source (Slater et al., 2007, Reed, 2008), the literature identifies a range of reasons for collaborative working. The development of a forum where industry, regulators and communities can work together provides a constructive arena for those affected by decisions to influence those decisions which may affect their activities (e.g. industry) and or quality-of-life (local communities). It can facilitate the breakdown of legislative, institutional and social barriers to changes, supporting the development of novel options which are workable and acceptable within national and local regulatory and operating contexts (van Herk et al., 2011). Partnership approaches can raise awareness of environmental issues, making use of the knowledge and expertise held by a wider range of stakeholders and generating approaches which have higher levels of regulator, organisational, sectoral and wider public acceptance, commitment and support (CIS, 2003). Within an I-WEB context, the IAB was the forum that brought individuals from a range of sectors together with a common goal of enhancing water resource management within not only Kazakhstan but the Central Asian region as whole. The IAB activities commenced with Kazakh partners pro-actively identifying and contacting a range of environmental protection specialists, water managers, policy makers and users to join discussions on enhancing the management of Kazakhstan's water resources. With national government recognition of the challenges being faced, there was interest in the IWEB IAB from a range of sectors, although bringing all interested parties together was a time-consuming process. It is well recognised that partnership working is a long process, that successful partnerships grow incrementally and evolve through the building of trust and shared experiences (Slater et al., 2007). The role of a 'local champion' – a person who is known by all parties, and is passionate and enthusiastic about the initiative in hand - is critical in the early stages of partnership building to both bring on board other partners and strengthen commitment to the process (Morris, 2006). Within I-WEB each of the local Kazakh university partners took the role of 'local champion', often using a combination of local knowledge and personal contacts to bring relevant stakeholders to the table together.

Methodologies and supporting tools for supporting implementation of IWCM

In implementing IWCM in practice, it is widely recognised that water resource (WR) systems are among the most complex systems to cope with when analysed from a risk management perspective. Risk management of WR systems has to include the identification, assessment, and prioritization of risks in order to implement coordinated actions to reduce, monitor and control the probability and/or the impact of any plausible events. A short list of the type of events that are usually of concern includes climate change, hydrological events, infrastructure safety, system management policies, effects of management policies in trans-boundary basins, accidental spills and incidents arising from other natural hazards. Alone or combined, these events define scenarios to be addressed by the risk management strategy. Ideally, any integrated WR strategic risk management platform should rely on a set of interconnected subsystems:

1. Events: Determination of plausible events and their probabilities.
2. Impacts: Assessment of every event impact.
3. Monitoring: System monitoring to anticipate events and to support the quantification of associated impacts.
4. Control: Mathematical models of the WR system – frequently based on a GIS platform – to predict and quantify the evolution of relevant parameters and variables of the system.
5. Actions: WR system protocols and procedures to make decisions in real time, and for the short and mid-terms.

The above subsystems are also connected through a loop because any taken action changes the probabilities and impacts of events. The whole platform has to be conceived and managed embedding the fundamental policy guidelines of the responsible organisation, and the participation of the stakeholders.

In general, most basin authorities and administrations, mainly in developed and populated regions, run different institutional programs or units that address the above subsystems. These programmes have usually focused on the most plausible events, many of them of hydrological origin, with droughts and floods often being the main concerns. However, risk associated to infrastructure failures or to the accidental introduction of pollutants into the water bodies should be also prioritized. A situation that requires special consideration is that of trans-boundary basins / WR systems. In this case, with different areas of the basin managed by different authorities, the existence of supra-national or supra-regional organisation to coordinate the basic policy objectives of the WR system is fundamental. This should be the "layer 0" underlying the participation of stakeholders and the existing risk management platforms in every sub-basin or subsystem. Without this basic coordination, risk management has to be based on partial treaties and slow and limited mechanisms; this situation would call for the use of specific tools such as the methods developed in games theory to support the decision-making process in the absence of ability to control sub-parts of the system. Madani (2010) reviews the applicability of game theory to water resources management and conflict resolution through a series of non-cooperative water resource games. The study includes case studies all over the world, including central Asia conflict on the legal status of Caspian Sea waters.

The implementation of a strategic risk management platform requires the availability and integration of data, models and networks, including at least the following:

- Historical records of the WR system to support conceptual models of subsystems, the analysis of trends in selected variables, extreme hydrological events estimations, and the calibration of mathematical models - both deterministic and statistical. These records should at least include data series of: runoff at selected control points along rivers, reservoirs storage and operation, piezometric levels in selected points in the main groundwater bodies, rainfall and other meteorological variables, basic quality parameters in surface water and groundwater at selected points, water consumption for irrigation, energy production and urban use, evapotranspiration, and series of any other relevant information regarding the characteristics of the WR system. The length of the series is relevant and if no information is available, or the series are very short, data series from similar locations might be useful.
- A complete and sound hydrological and hydrogeological description of the system.
- Monitoring networks to increase the length of existing historical records, and real-time networks connected to feed alert systems. The latter might require rainfall and rainfall intensity, river and/or channel flows, reservoirs levels, critical quality parameters, etc.
- Conceptual and qualitative models to understand the main subsystems flows and interactions, including surface water and groundwater.
- Rainfall – runoff sub basin models.
- Mathematical flow models of the main groundwater bodies.
- Flood simulation models for the main basins / sub basins with higher flood risks.
- Basin / sub basin models that integrate both surface water and groundwater systems with capabilities to simulate both flows and water quality.

Geographical information systems are basic tools to organize the basin information and in many cases they support the use of models for different purposes. There can be other types of water resources like water imported from other basins, desalinated water or treated water. In this case, the proper parameters to characterize these resources have to be also included in the above listing. Note that this is a basic list of required data, monitoring networks and modelling tools to build a strategic RM platform. In practice, it is necessary to develop Decision Support Systems (DSSs) that help the decision-maker to analyse and understand the dynamics of the system, foresee short and mid-term evolution, and to assess the impact of alternative decisions. DSSs are tools specifically designed for a given system and specific purposes (although the software platform can be design to be adapted to different basins). They usually integrate several mathematical models of the system, and stochastic simulators for hydrological inflows, that can cope with WR system operation under drought or flooding conditions, simulating short, mid and long term scenarios to remediate water scarcity or pollution problems, etc. The use and development of DSSs has historically run in parallel with the development of graphical capabilities in computers. An early DSS, under continuous development and well described in scientific and technical literature, is AQUATOOL, see Andreu et al. (1996). This tool has been evolving since the first releases and includes simulation and optimization of WR management accounting for the uncertainty of hydrological inflows in the system and many other features. It has been applied in many basins around the world (Spain, Argentina, Brazil, Italy, Mexico, Bosnia, Chile, Morocco, Algeria, Ecuador, Peru, etc.), and is supported by a friendly Graphic User Interface (GUI), spatially referenced, that allows its use by personnel with a low levels of training in the use of computers.

The use of risk as a criterion to manage a water resource (WR) system – risk based WR management - was described and applied by Capilla et al. (1998). Other authors, e.g. Rousta and Araghinejad (2015), illustrate how to incorporate multi-criteria decision making into a DSS using objective functions that include multiple goals. These goals or objectives can be as diverse as the fulfilment of ecological flows, the satisfaction of minimum levels of water demands, the maintenance of levels in lakes and reservoirs, the amount of energy generated in hydropower plants or maintenance of thresholds in the exploitation of groundwater bodies, etc. Note that the mathematical formulation of the multiple objectives optimization requires the definition of weights to be applied to reflect the importance to be apportioned to a prior decision reflecting the fundamental management policy.

Integrated water cycle management also requires working with scenarios that account for future climate change. In this case it is necessary to work with scenarios that are downscaled from General Circulation Model (GCM) results. The reports issued by the Intergovernmental Panel on Climate Change (IPCC), see IPCC (2014) are the primary source of information.

However, for specific geographical regions and basins, it is necessary to analyse which GCM best reproduces the local conditions, and to downscale the low resolution data provided to a scale that allows more accurate determination of impacts on water resources. Chirivella et al. (2015) show the results and methodology of a study in which dynamic and statistical downscaling methodologies are compared.

CONCLUSION ON THE BENEFITS OF IMPLEMENTING A WFD RISK MANAGEMENT APPROACH IN KAZAKHSTAN

Whilst both the EU and Kazakhstan are moving towards implementing an IWCM approach, the launch and phased implementation of the EU WFD has greatly accelerated progress towards its full implementation throughout Europe. As a single piece of legislation that all European Member States must implement, it requires the collection of data, involvement of all stakeholders and the development and implementation of science-based programmes of measures via the use of common methodologies and processes. All data collected is freely available with the use of common methodologies promoting the harmonization of management approaches both within and, crucially, between Member States. As such, this transparent approach facilitates transboundary dialogue with the development of common goals, languages and tools identified here as a strong mechanism for intra-regional co-operation irrespective of national boundaries. Therefore risk management is applied from strategic to local application scales.

Whilst the adoption of legislation such as the Kazakh Water Code indicates the recognition of, and priority placed on IWCM within Kazakhstan, no single country which shares transboundary waters can fully implement an IWCM approach in isolation. Whilst arguably not a short-term objective, the need for a Central Asian Water Framework Directive approach - which would co-ordinate and harmonize the emerging activities taking place across the region - is identified as a priority requirement. In developing such an over-arching framework, the current transboundary river basin agreements (Table 2) can be considered as an initial agenda for discussions to further develop and strengthen partnerships between business, regulatory and academic sectors at a national and international level to face the common need to implement robust approaches to water resource management in the face of a changing climate. Furthermore key aspects on the adaptation to climate change have to be considered including establishment of core principles and approaches, international commitments, policy, legislation and institutional frameworks, information and monitoring needs for adaptation strategies design and implementation, scenarios and models for impact assessment and water resource management, adaptation strategies and measures for financial matters and evolution purposes (UN ECE, 2009).

In developing and implementing approaches to ensuring water resources are available to meet the needs of current and future generations, Europe and Central Asian are facing many common challenges. The opportunity for closer collaboration between regions is highlighted here, with regard to both the need to develop a regional approach to IWCM and the role that individual countries can play in contributing to its delivery. With a specific focus on supporting the development of IWCM within Central Asia, key challenges identified by Lundy and Meyer (2014) included:

- Persuading neighbouring upstream countries that it is in their interest to work on a catchment basis
- Developing increased collaboration as opposed to competition over use of water resources within catchments e.g. to address tensions between agriculture and energy production
- Compliance with state legislative controls and facilitating stakeholder participation
- Scoping and developing a Central Asian Water Framework Directive; what can be learned from international best practice and mistakes?
- Developing the institutions and their capacities to successfully develop and deliver an IWCM approach which can respond to the challenges of a changing climate

By prioritising IWCM and investing strongly in their education system, Kazakhstan is now well positioned to take a leading role in supporting Central Asia’s transition to a region with a strong economy based on the sustainable management of its resources.

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